



(11) **EP 1 876 460 A1**

(12) **EUROPEAN PATENT APPLICATION**  
published in accordance with Art. 153(4) EPC

(43) Date of publication:  
**09.01.2008 Bulletin 2008/02**

(51) Int Cl.:  
**G01R 31/34 (2006.01) F03D 11/00 (2006.01)**

(21) Application number: **06725830.1**

(86) International application number:  
**PCT/ES2006/000149**

(22) Date of filing: **28.03.2006**

(87) International publication number:  
**WO 2006/106163 (12.10.2006 Gazette 2006/41)**

(84) Designated Contracting States:  
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR  
HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI  
SK TR**

(30) Priority: **08.04.2005 ES 200500820**

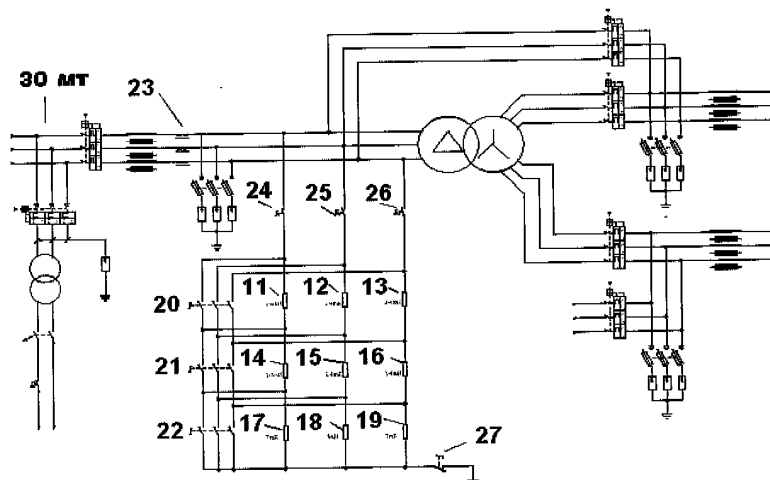
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(54) **LOW-VOLTAGE DIP GENERATOR DEVICE**

(57) The invention relates to a device for generating low-voltage dips in an electrical power generator (2), particularly an aerogenerator, consisting of: a circuit which is disposed between the control cabinet (4) of the generator and the output transformer (3) to the network (30),

comprising a transformer (31) and a plurality of in-series impedances (11, 14, 17; 12, 15, 18; 13, 16, 19) for each phase, having switches (24, 25, 26; 20, 21, 22; 27) associated therewith; and short-circuit generator means, selectively actuating the switches as a function of the type of voltage dip required.



**FIG. 2**

**Description****FIELD OF THE INVENTION**

[0001] This invention refers to a device for generating voltage dips in an electrical power generator and particularly on a wind turbine connected to the internal network of a wind farm.

**BACKGROUND OF THE INVENTION**

[0002] Sudden voltage steps can be caused in the connection to the electrical output network of a park of electric generators such as wind turbines, as a result of network defects. In such cases, implementing the proper protection disconnects the defective part of the network, producing a new voltage step in the opposite direction and restoring the voltage to the regular level, prior to the defect. The combination of both steps is known as a "voltage dip" which can be defined by two parameters: the depth and the duration of the voltage step.

[0003] A "voltage dip" can cause a wind farm to be disconnected from the network bringing the consequent harmful effects along with it, this therefore requires the behaviour of wind turbines in response to voltage dips to be tested

[0004] Previous techniques describe various different devices for generating voltage dips for different purposes.

[0005] Patent application WO0060430 describes a system for verifying the sensitivity of the components of a glass production plant in response to voltage dips that may occur, comprising a double cascade of industrial autotransformers connected to each phase of the current with at least two bipolar switches, which generates voltage dips in the machine output, in proportion to the values of the individual autotransformers located on the cascades. The system provides the option to vary the amplitude and the duration of the dip, along with the option to cause different voltage dips for each phase.

[0006] Patent US5886429 proposes a computer controlled and monitored testing station for testing the response of electronic equipment connected to the same to voltage dips and swells generated by the station.

[0007] Patent US 5920132 describes a device which is able to generate a reduced voltage by means of an autotransformer on low power industrial equipment, only valid for low voltage.

[0008] None of the aforementioned devices can be applied for verifying the behaviour of electrical power generators such as wind turbines in response to different types of voltage dips. One must consider that in each country there are different standards on this matter, therefore, a wind turbine manufacturer must be able to verify the effects of different types of voltage dips on its machines in order to guarantee compliance with the different standards. This invention proposes a solution to this problem.

**DESCRIPTION OF THE INVENTION**

[0009] The subject of this invention is a device for testing, at low voltage, the behaviour of an electrical power generator such as a wind turbine in response to a voltage dip similar to one which may occur on the network to which is it connected, with the wind turbine connect to the network.

[0010] The device comprises:

- a circuit located between the output of the machine's generator, which for the purposes of this descriptive report shall be understood to be located in a control cabinet, and the transformer of the MV network output with a low voltage wye-delta transformer for the power relating to the generator, a plurality of in-series impedances for each phase, a first group of switches associated with each phase respectively, a second group of switches associated with the in-series impedances and a switch for connecting the circuit to ground;
- mechanisms for generating short circuits by activating the first group of switches to select a single phase, two phase or three phase voltage dip, by activating the second group of switches to select the depth of the voltage dip and, optionally, by activating the third switch to generate a short circuit to ground;
- mechanisms for protecting the network during voltage dip generation and particularly an inductor to achieve a minimum amount of disturbance on the network during voltage dip generation.

[0011] Other characteristics and advantages of this invention can be found in the following detailed description, explaining its purpose, in relation to the attached diagram.

**DESCRIPTION OF FIGURES**

[0012]

Figure 1 shows the connection layout for the device for generating voltage dips, according to this invention.

[0013] Figure 2 shows a general layout of the device for generating voltage dips according to this invention.

**DETAILED DESCRIPTION OF THE INVENTION**

[0014] In a preferred embodiment, the invention device 1 is included in a platform or container located at the foot of the wind turbine 2, of a power rating ranging between 850 kW and 2W, and is connected between the control cabinet 4 located at the output of the wind turbine and the LV/MV transformer 3.

[0015] As shown in Figure 1, the device 1 is connected by means of port 7 to the control cabinet and by means

of port 8 to the transformer 3. The device 1 includes other ports 5, 6, 9 and a further port 10 for the connection to ground.

**[0016]** The device includes a circuit with a low voltage wye-delta transformer 31 for the power relating to the generator, three in-series impedances for each phase 11, 14, 17 (phase 1); 12, 15, 18 (phase 2); 13, 16 and 19 (phase 3); as shown in Figure 2, associated on one side with a first group of switches 24, 25 and 26 for each phase, and on the other side, with a second group formed by three switches 20, 21 and 22 for each impededer, preferably 600A, which, depending on their status, will produce short circuits of different characteristics, single phase or multi phase, and of different depths and durations in order to produce voltage dips of a maximum depth of 85%, and for a maximum duration of 500 milliseconds.

**[0017]** The invention device 1 also includes the necessary operation and control elements required for operating the aforementioned switches in order to generate different types of voltage dips.

**[0018]** The aforementioned device 1 is also equipped with temperature sensors to control its correct operation, with said temperature having to be within a range of 60°C and 120°C.

**[0019]** The device 1 also includes an inductor 23, preferably of 60  $\mu$ H, allowing a minimum level of disturbance to the network during the generation of voltage dips for the wind turbine 2, so that the rest of the wind turbines on the park can continue to operate normally.

**[0020]** The aforementioned voltage dip, single phase or multi phase, with or without ground, is generated by short circuits being produced between phases or between phases and ground. According to the invention device 1, switches 24, 25 and 26 are responsible for producing the short circuit for one, two or three phases, whilst switches 20, 21 and 22 are responsible for controlling the depth of the voltage dip produced, with switch 27 being that which connects the neutral to ground. The device 1 takes its power supply directly from the LV network.

**[0021]** The device 1 according to this invention is, therefore, capable of providing 8 different types of voltage dips, in regard to depth and duration time, based on the single phase or multi phase short circuits generated, described below, thus testing the response of the control cabinet 4 of the wind turbine 2:

- a three phase short circuit will generate a long voltage dip (prolonged duration time) or a small voltage dip (of little depth);
- a single phase short circuit will generate a long voltage dip (prolonged duration time) or a small voltage dip (of little depth);
- a two phase short circuit with ground will generate a long voltage dip (prolonged duration time) or a small voltage dip (of little depth);
- a two phase short circuit will generate a long voltage dip (prolonged duration time) or a small voltage dip (of little depth).

**[0022]** Other relevant elements of the device are as follows:

- Voltage and current measurement points.
- Bridging mechanisms which enable the direct connection of the wind turbine 2 to the network 30.
- Mechanisms for switching between "normal" mode, where the device is disconnected at the transformer 3 and a "dips" mode where the device is connected allowing the field test times to be optimised.

**[0023]** In the preferred embodiment described above, modifications within the scope defined in the following claims can be made:

### Claims

1. Device (1) for generating voltage dips in an electrical power generator (2) with a control cabinet (4) at the output of the generator and an output transformer (3) to an electricity network (30) **characterised in that** it comprises:
  - a) a circuit located between the control cabinet (4) of the machine and the output transformer (3) to the network (30) with a transformer (31), a plurality of impedances (11, 14, 17; 12, 15, 18; 13, 16, 19) in-series for each phase, having a first group of switches (24, 25, 26) associated respectively with each phase and a second group of switches (20, 21, 22) associated with the in-series impedances, and a switch (27) for connecting the circuit to ground;
  - b) mechanisms for generating short circuits by activating the first group of switches (24, 25, 26) in order to select a single phase, two-phase or three-phase voltage dip, by activating the second group of switches (20, 21, 22) in order to select the depth of the voltage dip and by activating the third switch (27) in order to generate a short circuit to ground; and
  - c) mechanisms for protecting the network (30) during voltage dip generation.
2. Device (1) for generating voltage dips in accordance with claim 1, **characterised in that** the mechanisms for protecting the network (30) comprise an inductor (23) to obtain a minimum level of disturbance to the network during voltage dip generation.
3. Device (1) for generating voltage dips in accordance with claim 1, **characterised in that** the electricity generation machine (2) is a wind turbine.
4. Device (1) for generating voltage dips in accordance with claim 3 **characterised in that** the power of the wind turbine (2) is between 850 kW and 2 MW.

5. Device (1) for generating voltage dips in accordance with claim 3 **characterised in that** it also includes bridging mechanisms enabling the wind turbine (2) to be directly connected to the network (30).

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6. Device (1) for generating voltage dips in accordance with claim 3 **characterised in that** it also includes switching mechanisms for connecting /disconnecting it to/from the transformer (3).

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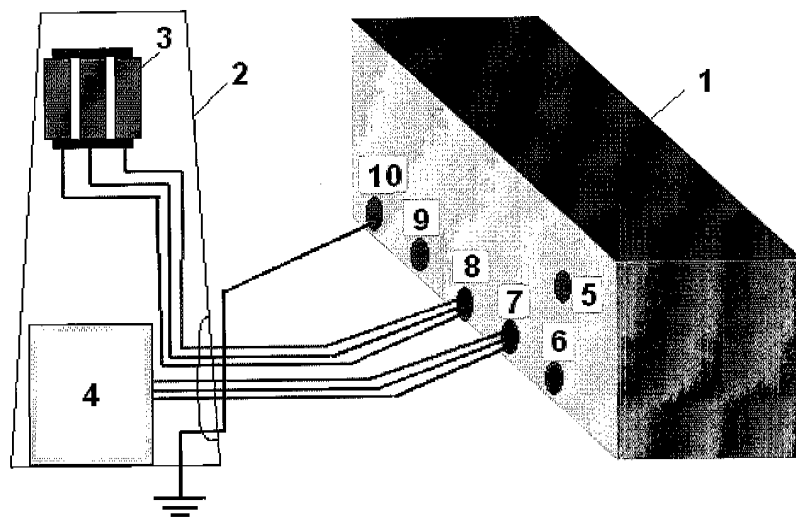
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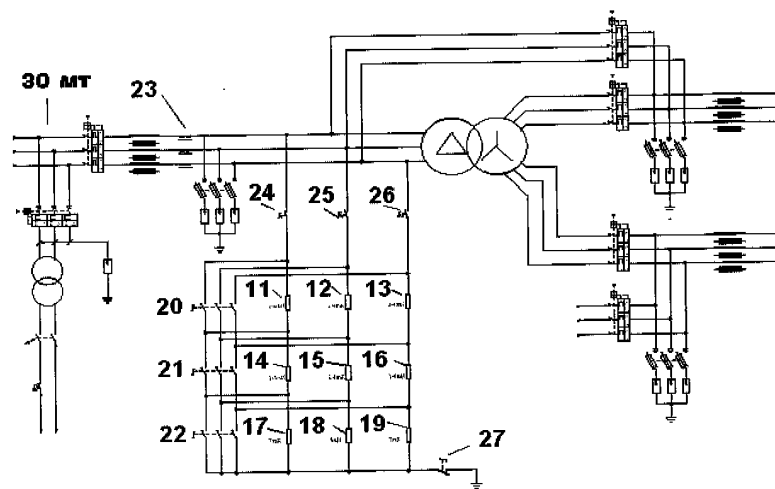
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**FIG. 1**



**FIG. 2**

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/ ES 2006/000149

## A. CLASSIFICATION OF SUBJECT MATTER

see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01R+, F03D+, H01C+

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CIBEPAT, EPODOC, WPI, ELSEVIER, INSPEC

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4445047 A (CANNON) 24.04.1984, Col. 3, líns. 50-61, col. 4, líns. 49-65, figure 3.	1-5
A	US 5424588 A (CANTOR et al.) 13.06.1995, Col. 5, líns. 42-43, col. 7 líns. 63-68, figures 5 and 8.	1-5
A	US 6833636 B1 (NESTEL et al.) 21.12.2004, the whole document.	1-5

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance.		
"E" earlier document but published on or after the international filing date		
"I" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"O" document referring to an oral disclosure use, exhibition, or other means	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other documents, such combination being obvious to a person skilled in the art
"P" document published prior to the international filing date but later than the priority date claimed		
	"&"	document member of the same patent family

Date of the actual completion of the international search

25 agosto 2006 (25-08-2006)

Date of mailing of the international search report

31 Agosto 2006 (31-08-2006)

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Form PCT/ISA/210 (second sheet) (April 2005)

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/ ES 2006/000149

Patent document cited in the search report	Publication date	Patent family member(s)	Publication date
US4445047A A	24.04.1984	NONE	-----
US5424588A A	13.06.1995	NONE	-----
US6833636B B	21.12.2004	NONE	-----
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INTERNATIONAL SEARCH REPORT

International application No.  
PCT/ES 2006/000149

CLASSIFICATION OF SUBJECT MATTER

*G01R 31/34* (2006.01)  
*F03D 11/00* (2006.01)

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- WO 0060430 A [0005]
- US 5886429 A [0006]
- US 5920132 A [0007]

**PUB-NO:** EP001876460A1  
**DOCUMENT-IDENTIFIER:** EP 1876460 A1  
**TITLE:** LOW-VOLTAGE DIP GENERATOR  
DEVICE  
**PUBN-DATE:** January 9, 2008

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**APPL-NO:** EP06725830

**APPL-DATE:** March 28, 2006

**PRIORITY-DATA:** ES200500820A (April 8, 2005)

**INT-CL (IPC):** H02J003/40

**EUR-CL (EPC):** H02J003/40

**ABSTRACT:**

The invention relates to a device for generating low-voltage dips in an electrical power generator (2), particularly an aerogenerator,

consisting of: a circuit which is disposed between the control cabinet (4) of the generator and the output transformer (3) to the network (30), comprising a transformer (31) and a plurality of in-series impedances (11, 14, 17; 12, 15, 18; 13, 16, 19) for each phase, having switches (24, 25, 26; 20, 21, 22; 27) associated therewith; and short-circuit generator means, selectively actuating the switches as a function of the type of voltage dip required.